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Optical Disc Data Archiving

A New Age of Cold Data — The Storage Revolution Begins Now

Written in cooperation with Fujiwara-Rothchild, Ltd.

White Paper

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A New Age of Cold Data — The Storage Revolution Begins Now

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Publisher: Panasonic Corporation Connected Solutions Company, Storage Business Development Center
1-15 Matsuo-cho, Kadoma-shi, Osaka-fu, Japan 571-8504
https://panasonic.net/cns/archiver/
optical-storage@gg.jp.panasonic.com

Written in collaboration with Fujiwara-Rothchild, Ltd.
2-11-3-4F, Iwamoto-cho, Chiyoda-ku, Tokyo, Japan 101-0032
http://www.fujiroth.com/english/

1 Executive Summary

From Cemetery of Data to Treasure Trove of Data

Posted videos and photographs in SNS are frequently accessed right after they have been uploaded, but that frequency of access drops off dramatically within a few days. Such data, with low access rates, is called "cold data." Cold data can be moved for long-term storage into what are called "Cold Archives."

Traditionally, cold data has been treated as "data with lower value," but the view of cold data has shifted in recent years to be seen as important assets that have the potential for future corporate value. The volume of collected data is expected to keep increasing along with the popularization of IoT devices. As such, it is essential to establish a process to securely archive this big data (the majority of which is cold data) so that it can be analyzed by Artificial Intelligence (AI) to create new value for the development of next generation industries.

Optimal Storage Media for Cold Archives

Optimal cold archive storage has to meet certain requirements such as readability, authenticity and stability. Further, it is anticipated that successful storage media options would need to greatly reduce the total cost of ownership.

Requirements for the physical characteristics for storage media include the following: the recording method must be tamperproof, the memory needs to be non-volatile, it needs to have long useful life of 100 years or more, it must be compatible with various systems, and it must have random access capability. It is also expected to minimize the cost for long-term storage with such characteristics.

In the storage with layered structure shown in Figure 1, data that has reduced access frequency is recorded into "active archives," and increasing amounts of duplicated data are being recorded in the layer of "deep archives." In these cases, storage media must have excellent efficiency in space utilization (such as storage capacity per area) in order to store massive amounts of data.

Comparing the characteristics of existing storage media formats, only optical discs can currently meet all of the above-mentioned requirements. As the roadmap for increased storage capacity in the optical disc standard for "Archival Disc" indicates, optical discs are likely to maintain optimal characteristics for storage of cold archives into the foreseeable future.

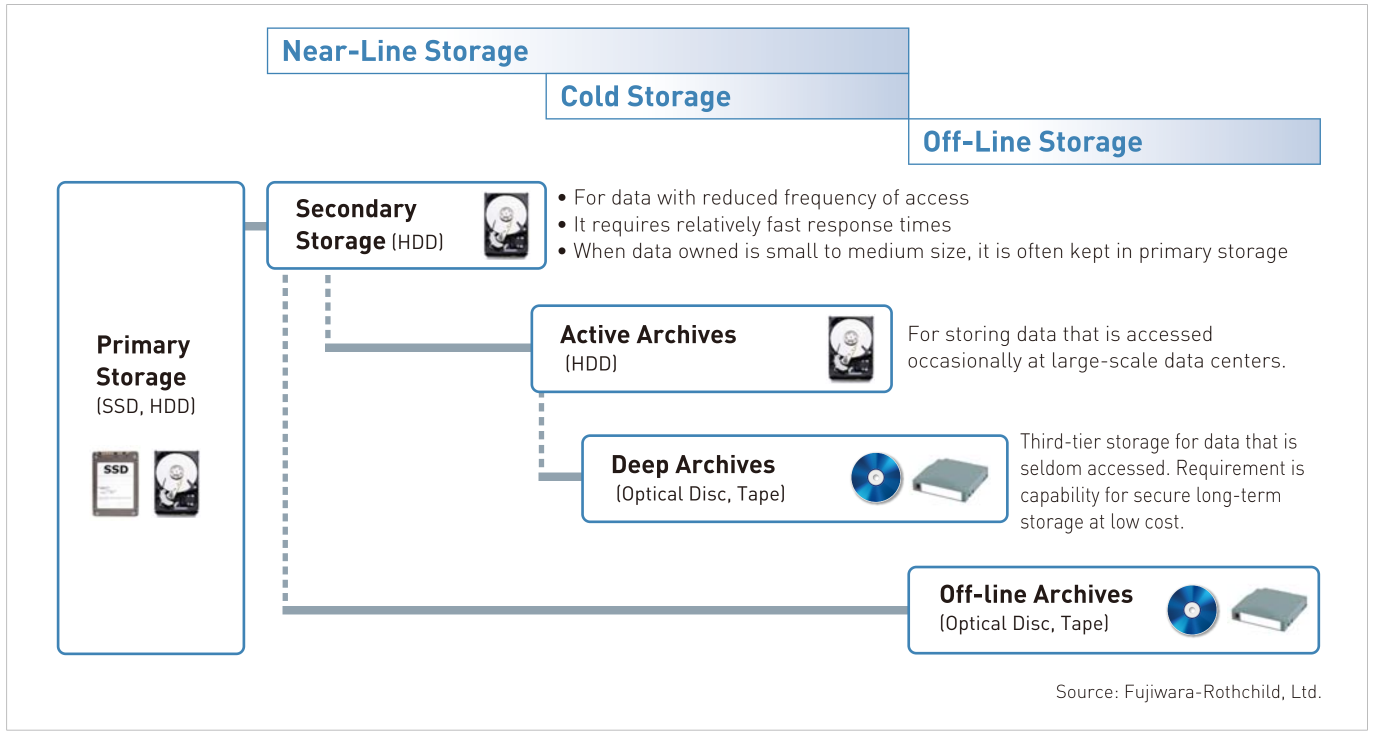
Panasonic has been the driving force for the optical disc markets for consumer and business use for decades and has started showing its presence in the cold archive area of the enterprise market.
This white paper discusses the unique characteristics of the large-capacity optical disc data archiving system, "Data Archiver," that Panasonic has produced as well as the expansion of its new solutions and case studies of its utilization.

2 Demand Trend for Cold Archives

Layered Structure of Storage

As defined in Figure 1, cold archive storage is categorized as active archives, deep archives, and off-line archives in the layered structure chart. Active archives need to have consistent reading speed as the data is seldom rewritten but is often accessed. For deep archives and off-line archives, the data is almost never accessed, so the priority is to be able to store the data safely over the long term at a low cost.

Figure 1 Layered Structure Storage Management

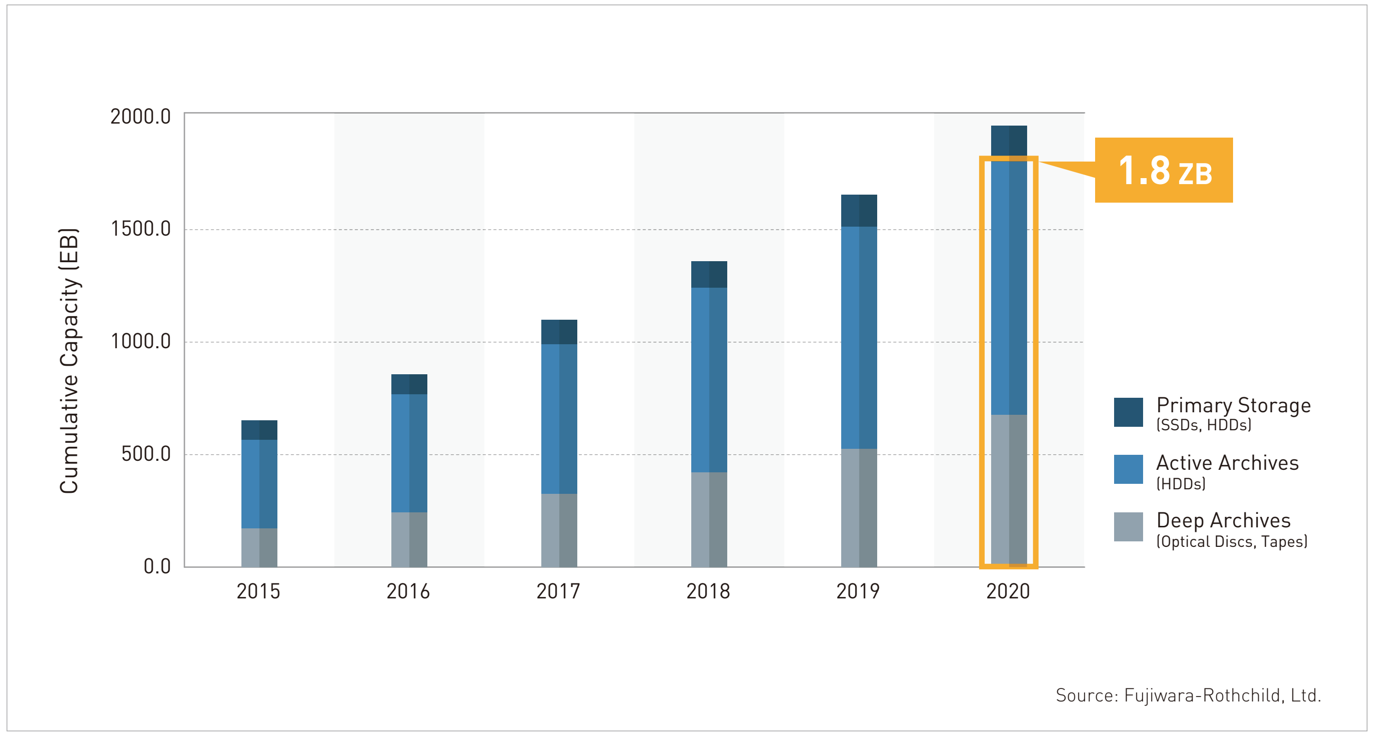


Exponential Growth of Cold Data

Worldwide output of digital data is expected to reach 44 ZB in 2020. This does not necessarily mean that all of that data will need to be stored. However, the trend for increasing amounts of data owned by individuals and organizations around the world will not change. Figure 2 shows the trend forecast for capacity of storage devices in the enterprise market, such as data centers.

Note that about 90 % of the total capacity is occupied by the storage of cold archives (active archives plus deep archives). As the volume of produced data increases over time, cold data increases, resulting in a continuous increase in required storage capacity. It is estimated that there will be 25.3 % average annual growth in required cumulative capacity from 2015 to 2020, and 1.8 ZB of storage capacity for cold archives are projected to be in operation in the enterprise market in 2020.

Figure 2 Trend Forecast for Cumulative Capacity in Enterprise Storage (Unit: EB)



Note:
• Service lifespan estimated as 4 years for HDDs and SSDs, 100 % cumulative for tape and optical disc systems.
• Primary storage figures come from high-speed HDD and SDD totals. Active archive figures come from HDD totals (used for near line). Deep archive figures come from tape system and optical disc system totals.
• Cumulative storage capacity was calculated based on the estimated service life of systems, with HDDs and SSDs at 4 years, tape systems at 30 years, and optical disc systems at 50 years.

The Need for Cold Archives

According to the IDC White Paper sponsored by Fujitsu, it is reported that only 10 % to 20 % of company data is found to be in active use, while the rest is accessed rarely or never. If this cold data is migrated out of primary storage and into cold archives, the active data set becomes smaller and therefore easier to back up and faster to recover, provision, and manage.*

* Source: IDC White Paper sponsored by Fujitsu "Meeting Backup and Archive Challenges — Today and Tomorrow"

(1) through (3) are basic requirements, and (4) and (5) are methods to reduce the risks of losing or damaging data.

Figure 3 **Purposes of Archiving**

(1) Archives for Compliance	• For regulations (for management of public documents, electronic accounting books, e-books, product liability, SOX compliance, medical doctors, etc.) • For compliance in industries (financial, medical, pharmaceutical, construction, manufacturing, etc.) • For accountability to various stakeholders, for ISO standards with record-keeping requirements, etc.
(2) Archives for Historical Assets, Media Assets, etc.	• Digitization and archiving of historical assets in national archives, libraries, museums, etc. • Archives of video assets for movie and television industries. • Corporate archives for preservation of corporate knowledge and culture.
(3) Archives for Data Analysis	• Creating value through the collection and analysis of big data. • Collecting and sharing data from experiments and observations in the scientific field.
(4) Mirroring Active Archives	• Storing in different types of storage for duplicated storage of active archives.
(5) Archives for Emergency Preparedness	• Storing copies of data offsite to protect data from natural disasters, etc. (Utilization of physical storage or cloud storage)

Source: Fujiwara-Rothchild, Ltd.

Among the above five types of archives, the demand for (4), mirroring of active archives, is expected to grow quickly. In gigantic data centers, such as what SMS operators own, cold data has been stored in storage that is suited for active archives, mainly composed of HDDs. These provide accessible storage, but the media is not suited for long-term storage. Therefore, it is prudent to store a copy of that data in storage media that is low in cost and has long-term durability as it would be faster to restore files from this media than using off-line backup in case the data is damaged in active archives.

Example of National Security Requirements

Double and triple security measures need to be taken for archiving important data relating to national security. The methods used for archiving such data can be useful for private organizations that require high-level security.

For example, US-CERT (United States Computer Emergency Readiness Team), which is an organization for information security under the U.S. Department of Homeland Security, has introduced the "3-2-1 Rule" to reduce the risk of data loss in communication documents using the recommended policies for data backup. Figure 4 provides an overview of the rule.

Figure 4 **Concept of the "3-2-1 Rule"**

3. Keep 3 copies of any important file. 1 primary and 2 backups.
2. Keep the files on 2 different media types to guard against different types of hazards.
1. Store 1 copy offsite (e.g. outside of your home or business facility).

The idea of the 3-2-1 Rule has been popularized in countries and companies around the world. It is important to follow these rules completely or partially in order to protect valuable data from the risk of loss.

Physical Requirements for Storage

In order to achieve the goals for archives shown in Figure 3, storage media needs to meet three primary requirements, "readability," "authenticity," and "stability." If these are achieved, users can read necessary data at any point during the storage period while preserving the data in a condition that cannot be overwritten without proper authorization. Storage that cannot meet above three requirements cannot be claimed to be suitable for archiving. Other important characteristics, in addition to three requirements above, are: "searchability," "sustainability," "confidentiality," and "economy."

Figure 5 Requirements for Archives

Readability	• Recorded data can be displayed or output as a document using a PC. • Data needs to be readable 50 to 100 years after it is recorded. For this, the drive and software have to be able to function as a reading device for the data.
Integrity and Authenticity	• Integrity: Able to confirm the author of the document and the time it was created. Able to verify the electronic document against a printed document to confirm that they are exactly the same. • Authenticity: Documents cannot be altered or erased during the storage period. In cases where alterations are made, those changes need to be identified.
Stability	• Ensuring readability and authenticity throughout the storage period defined by regulations or corporate policy.
Searchability	• Being able to search electronic documents, etc. as needed as one of the requirements to ensure readability.
Sustainability	• Storage has to take into consideration reducing CO_2 emissions and other environmental burdens to be part of sustainable information infrastructure.
Confidentiality	• Refuse access to the data from unauthorized users. Storage has to be managed to prevent information theft, leaks, eavesdropping, alteration, and deletion.
Economy	• Understand and minimize the initial cost for implementation and ongoing operational costs.

Source: Fujiwara-Rothchild, Ltd.

Regarding the suitability of conventional storage media (HDDs, tapes, optical discs) for the above requirements, optical discs are by far the most suitable at this point, as shown in Figure 6. The superiority of optical discs becomes even more clear when considering the length of the storage period.

Figure 6 Comparison of Storage Media on the Three Primary Requirements

	HDDs	Tapes	Optical Discs
Readability	× Huge cost incurred to manage operations, such as frequent replacement and regular inspection and maintenance to ensure readability.	△ Compatibility with two generations back. Frequent migration is necessary for long-term storage.	○ Capable to sustain readability for long term as it is non-volatile memory.
Integrity and Authenticity	× Can be overwritten as it is magnetic recording media. Special measures, such as security software, are needed to prevent alterations.	△ Can be overwritten as it is magnetic recording media. Special measures, such as security software, are needed to prevent alterations. WORM function available.	○ Cannot be overwritten as recording utilizes physical pitting to write data. The media itself has authenticity.
Stability	× Drives with mechanical parts have an estimated lifespan of about 4 years.	△ Estimated lifespan of about 30 years. Migration is necessary before the end of the lifespan.	○ The recording media is non-organic and has an estimated lifespan of 50 to 100 years.

Source: Fujiwara-Rothchild, Ltd.

3 Advantages of Optical Disc Data Archiving

Assessment Based on the Requirements for Archiving

Whether storage media can meet the requirements for archiving depends on its physical characteristics. This chapter details the points shown in Figure 7. The implications of using cloud services for long-term archives are included at the end of this chapter.

Figure 7 Physical Characteristics of Storage Media and Suitability for Archiving

● Most Superior ○ Superior △ Rather Inferior × Inferior

	HDDs (for near line)	Tapes	Optical Discs
Data Security	△	△	●
Non-Volatility	△	△	●
Long Life	around 4 years	10-30 years	50-100 years
Durability	△	△	●
Compatibility	○	△ (up to two generations back)	●
Total Cost of Operation (TCO)	×	△	●
Random Access Capability	●	△	○
Transfer Rate	●	●	○

Source: Fujiwara-Rothchild, Ltd.

● Data Security

For data security, the recording media itself needs to have a non-overwritable structure. The write-once characteristic of optical discs uses physical changes to record data and makes overwriting physically impossible, so it is structurally very secure. Magnetic recording media in HDDs and tape systems can be repeatedly overwritten physically, so additional special measures, such as software, are needed to ensure the security of these systems.

● Non-Volatility

Magnetic recording media, such as HDDs and tapes, have the risk of losing recorded data when subjected to strong magnetism. Optical discs that use physical changes for recording data have non-volatile memory.

Non-volatility is the most important characteristic to assess the feasibility of ultra-long-term storage up to 100 years.

● Long Life/Durability

Longevity of data storage can be affected by the structure and the quality of the materials of the storage media in addition to environmental factors. These create the difference in the longevity of storage: less than 5 years for HDDs, and 10 to 30 years for tapes.
HDDs employ a system that combines a mechanical drive and recording media, and the longevity of these drives is generally short. Tape systems utilize long rolls of ultra-thin (several μm) film which is prone to breakage. Optical discs have a stable recorded condition utilizing physical changes to non-organic material, and this media has the longest storage capability. In the case of "Archival Disc," the optical disc standard for professional use that Panasonic and Sony developed jointly, it has an estimated lifespan of over 100 years.*

*The estimated lifetime based on acceleration tests that are being conducted by Panasonic. Note that it is not a guaranteed value.

● Compatibility

Unless changes are made in the fundamental principles of recording, optical discs can remain compatible with discs from different generations going into the future. For example, in the after-mentioned roadmap of Archival Discs, as compatibility is maintained for drives from different generations, no work and no cost for migration would be necessary.
In the case of tapes, compatibility may be lost due to the change of specifications to increase memory capacity. Provided that new generation products are introduced every 2 to 3 years and the compatibility is basically supported up to the previous two generations, migration would be necessary about once every 7 years to maintain readability of records from the past.

● Total Cost of Ownership (TCO)

It is possible to use short life storage for storing data over the long term if users don't mind to invest in the related replacement costs. That option might be feasible as long as the data volume is small. However, to maintain that option, disregarding the trend for ever-increasing amounts of cold data, the long-term costs could become enormous.

Comparing the cost performance of HDDs, tapes and optical discs over 20 years of storage for 1 PB data, the following is the breakdown of the TCO.

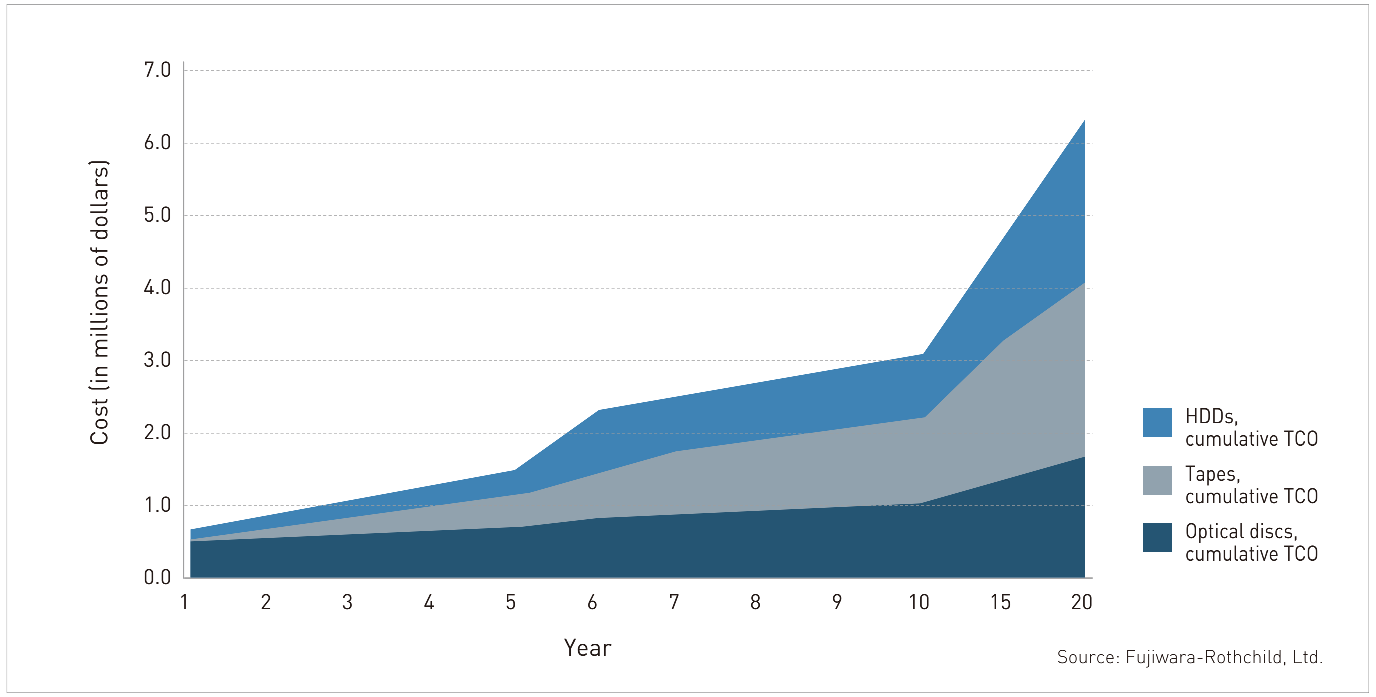
- Implementation costs for hardware and software
- Operational costs for information system division
  (replacement in case of trouble, regular maintenance, electricity, data migration, etc.)

Figure 8 shows typical cumulative costs* in dollars adding up operational costs, including estimatable costs (yearly electricity consumption, regular system upgrades, migration of data, etc.). There is not a big difference in the initial or short-term costs, but there are substantial differences looking at it over a 20-year period.
For example, HDDs incur 4 times as much cost compared to optical discs. In the case of tape systems, migration costs stand out as compatibility between systems can typically only be sustained over two generations.
Optical discs do not incur large costs except for regular maintenance of the library. Thus, when considering to build a data archive system that would be used for more than 5 years, it is essential to consider optical discs.

It should be noted that it was not easy to lower the initial costs for utilizing optical discs as compared to utilizing HDDs for archiving. The reason for this is that optical disc storage systems requires initial investment in hardware, basically starting from scratch, while the costs for utilizing HDDs are mainly for expanding facilities. However, as shown in the section on Archival Disc standard and roadmap, the advancements in optical discs for the enterprise market have led to lower the initial cost for utilizing optical disc systems to make them cost-competitive with HDDs.

* Definition of "typical": The above example is the result of an estimate of the all initial costs including storage, software, installation in the facility for a mid- to large-size company. Gigantic data centers with large data volume, from several EB to several ZB, were excluded from this estimate as they often operate with substantially lower costs (sometimes a whole digit different).

Figure 8 Comparison of Cumulative TCO of Storage Media (20 years)



Comparison of the cumulative TCO over the long term in a typical example.
Initial installation cost of storage for 1 PB and the following operational costs were calculated.

- HDDs: Replacement of drives, regular server maintenance, migration of data, energy consumption, etc.
- Tapes: Regular maintenance of the library, migration of data, etc.
- Optical Discs: Regular maintenance of the library, etc.

● Random Access Capability

In cases where the purpose of archiving is to store data for a certain period for compliance and there was almost no need to read the data, demand for random access capability is not strong. However, for data that needs to be accessed periodically to some extent, random access capability is an important factor.
Especially in the movie and video production industries, the need for random access capability in the later process of production is strong. For instance, users who are using LTO systems in post-production say that they are not comfortable having to wait for tape going back and forth to retrieve data. For the improvement of workflow efficiency during editing or searching through video/images, the random access capability of optical discs is more efficient.

● Transfer Rate

The typical transfer rate when archiving data to an optical disc using one drive is around 30 MB/s. However, in case of Panasonic's Data Archiver, which is a system specially designed for archiving large amounts of data and can simultaneously read from or write to 12 optical disc sides,* it is possible to achieve high-speed transfer rates of around 360 MB/s. The transfer rate of tape systems, which are said to be able to write sequential files quickly, is around 300 MB/s with LTO7 (when not compressed).

*In the case of minimum configuration, the system can simultaneously read from or write to 2 sides of each optical disc using 6 drives.

Implications of Using Cloud Service

There are many different types of cloud-based storage services, so it is difficult to make a general comparison. However, there are some cautions regarding cloud-based storage services for the purpose of long-term archiving.

For example, the service can be modified or terminated at the convenience of the service provider, so the user has to decide if the service can be trusted for long-term storage for important information assets. The same thing can be said for safety and security of the data.

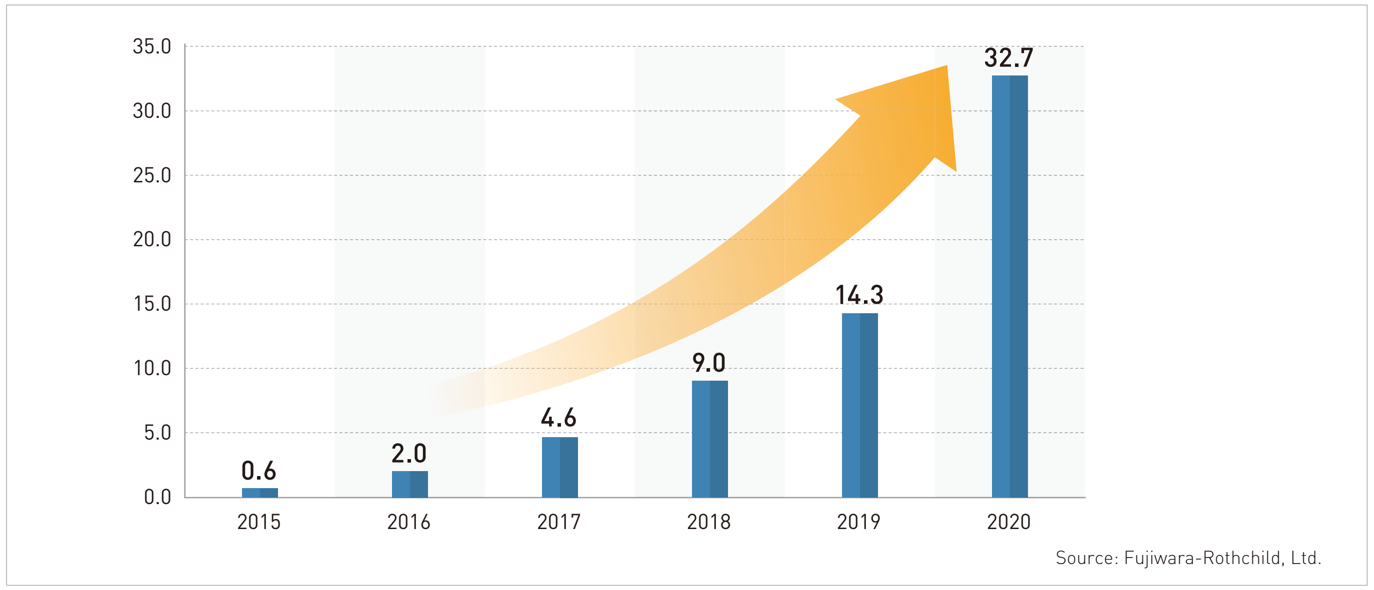
In addition, TCO needs to be carefully examined. Although using cloud storage does not incur many initial costs, and often the unit cost for storage is set at a low price, there are cases where the fee goes up for reading data, or the cumulative costs could jump as data size increases greatly or parallel to the duration of the storage.
For storage of large volumes of data being stored for more than 5 or 10 years, TCO reduction can be achieved more easily by using optical discs that have a long lifespan for archiving data.

Demand Trend for Optical Disc Data Archiving

Figure 9 shows the trend of volume for the shipment of optical discs in the enterprise market. From 2015 to 2020, rapid growth of the compound annual growth rate (CAGR), 94.5 % growth, is expected. The significant improvements in storage capacity and data transfer rates of optical discs in recent years are major growth factors as those have been pushing the utilization of cold archives for near-line storage, in addition to conventional off-line archiving.

For example, a major SNS operator in the U.S. began testing operations for an optical disc data archiving system in 2015 and is planning to utilize a system with higher-density Archival Discs. This is a sign that the utilization of optical discs is reaching a new stage in the enterprise market.

Figure 9 Trend Forecast for the Shipment of Optical Discs in the Enterprise Market (Unit: EB)



Source: Fujiwara-Rothchild, Ltd.

Social Impact of Sustainable Storage Media

In our contemporary society, 80 % of data created will become cold data. If we keep using storage media which is not optimal for long-term archiving, that would result in tremendous increase of power consumption and CO_2 emissions. We should carefully consider this as social information infrastructure choices can have a significant impact on the environment.

The power consumption of optical disk archives is low, and they do not need air conditioning or frequent migration of data. In addition, data can be stored for a long time, from 50 to 100 years. Thus, optical disk archives are the most sustainable storage media currently available.
Now is the time to accelerate the construction of sustainable storage systems utilizing optical discs.

Figure 10 The Philosophy and Significance of Optical Disc Data Archiving

4 Panasonic Is Taking on New Challenges

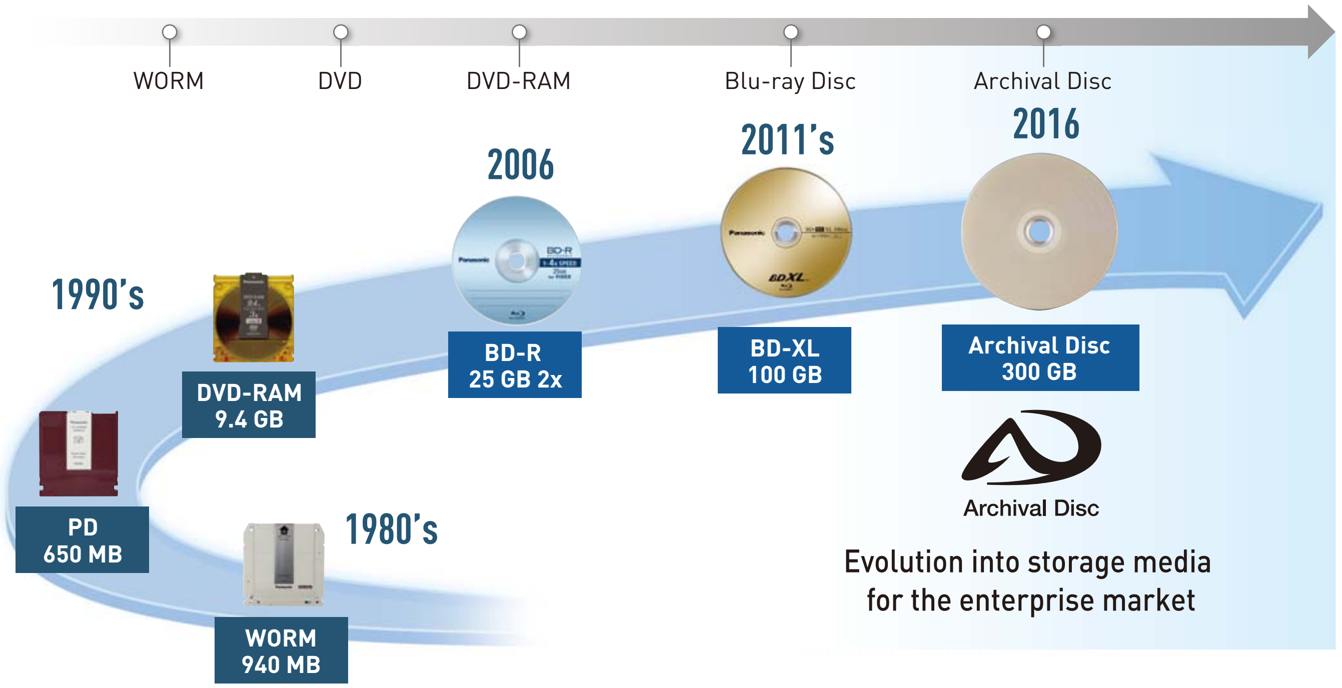
Contributions to the Cold Archive Market

Panasonic has long been striving for standardization of Blu-ray discs for consumers and the development of products for its application. In particular, the company has been playing a central role for the establishment of standards for BD-R XL (3 layers) 100 GB and BD-RE XL (3 layers) 100 GB, responding to the needs associated with the exponential increase in the volume of data.

Applying expertise and technology that the company developed in consumer products, Panasonic developed the Data Archiver, LB-DM9 (with a maximum storage capacity of 108 TB/unit), using 100 GB optical discs from BD-XL, entering the enterprise market in earnest. Since then, the Data Archiver has evolved into the "freeze-ray" archival system for data centers through a collaborative development with a major SNS operator in the U.S. Panasonic started shipping a new system, the LB-DH7 Series, using 300 GB Archival Discs (achieving a maximum storage capacity of 1.9 PB per rack), in fiscal 2016.

Panasonic is transforming the cold archive market by integrating its strengths in engineering and product development, including high-density technology for optical discs, essential device technology (drives, related robots, etc.) and the development of library software that makes system management easier.

Figure 11 History of the Development of Optical Discs by Panasonic



Evolution of the Data Archiver

Recording media using single optical discs had been utilized for off-line archiving, but the Data Archiver that Panasonic has developed is different in that it can meet the demands for cold archives for data with more than dozens of PB in a huge data center. As previously mentioned, new applications to meet this demand have led to rapid increases in the utilization of optical discs in the enterprise market.

Figure 12 shows the exterior of the latest Data Archiver "LB-DH7 Series." The minimum configuration includes one bottom module (magazine transfer device), one base module (magazine reading/writing device) and one extension module (with a writer unit). The base module can be mounted with up to 76 3.6-TB magazines and can respond to increasing data storage needs by adding extension modules with writer units. The data transfer rate for an extension module with a writer unit can reach 360 MB/s.* Even higher transfer speeds can be achieved by adding extension modules to the flexibly designed system.

* Unit measurement value obtained in a Panasonic standard test. Actual writing speeds will vary depending on environmental conditions, such as the server.

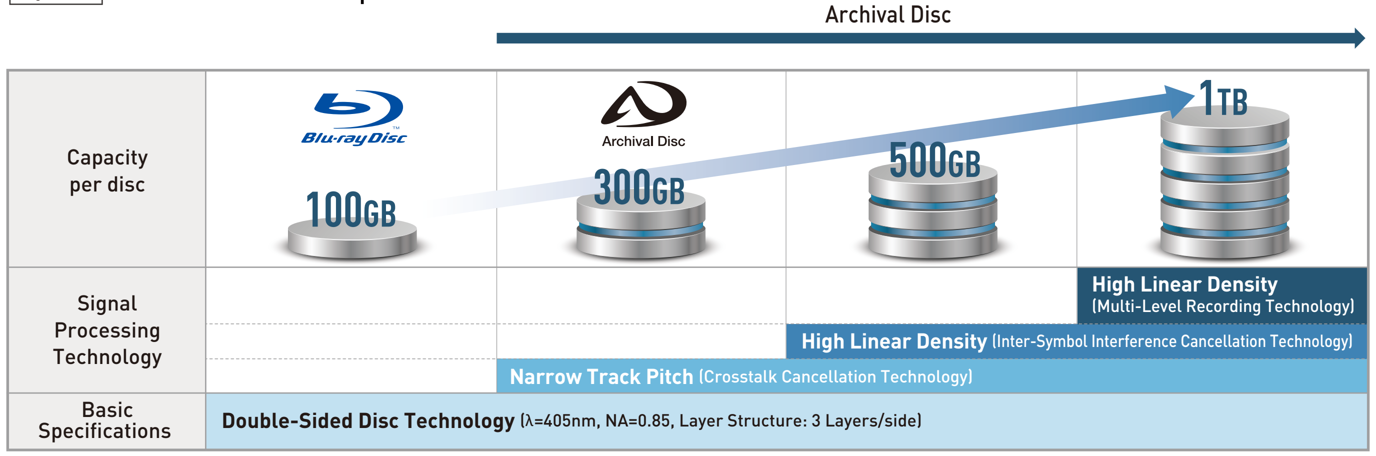
Figure 12 Exterior of the Data Archiver

* The photos show Data Archiver in a rack.

Archival Disc Standard and Roadmap

The requirements for storage media for cold archives demand high quality, including high reliability for a long period, large storage capacity, and a low cost per bit. Thus in 2014, Panasonic developed the large-capacity optical disc standard, "Archival Disc" in cooperation with Sony and planned a roadmap (Figure 13) for increased capacity, up to 1 TB.

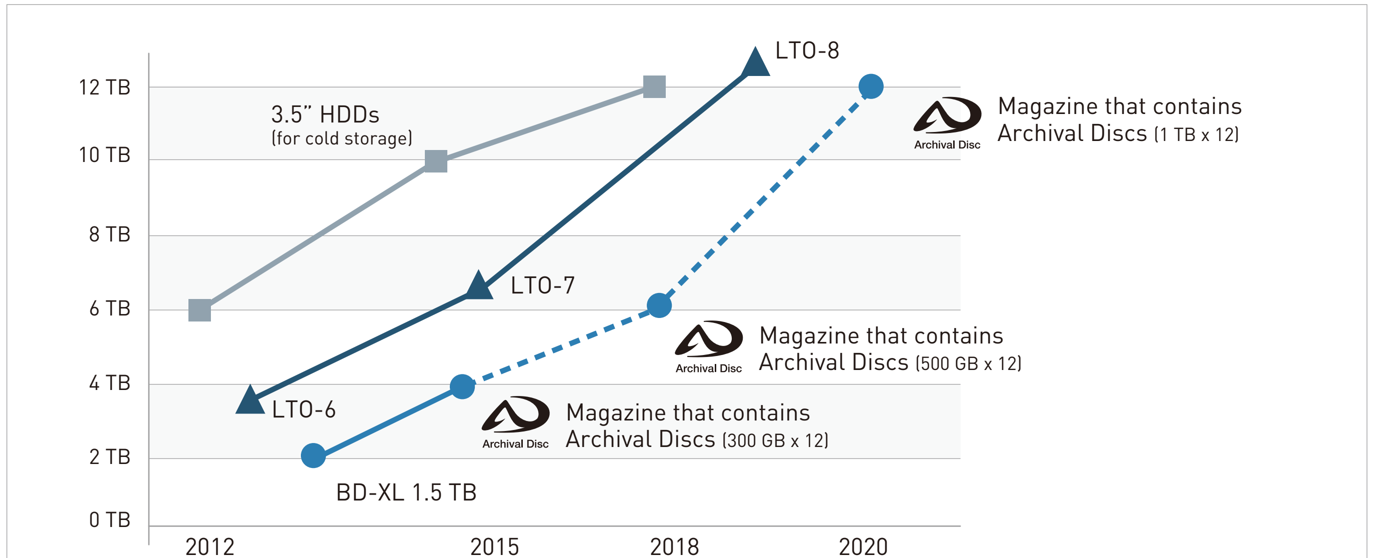
Figure 13 Archival Disc Roadmap



As for the first-generation 300 GB Archival Disc, a conventional triple-layer, double-sided disc is used with simultaneous reading and writing on both sides, meeting the demand for large storage capacity and improvement in data transfer rates. If the three-layer structure is maintained and manufacturing costs do not increase significantly, the cost per bit would keep falling despite increases in storage capacity up to 1 TB.

As shown in Figure 14, the storage capacity of storage media is certainly expected to keep growing into the future. Note when comparing the storage capacity among different types of storage media, it is reasonable to count a magazine containing 12 optical discs as a single unit as an Archival Disc.

Figure 14 Trend Forecast for Storage Capacity of Storage Media

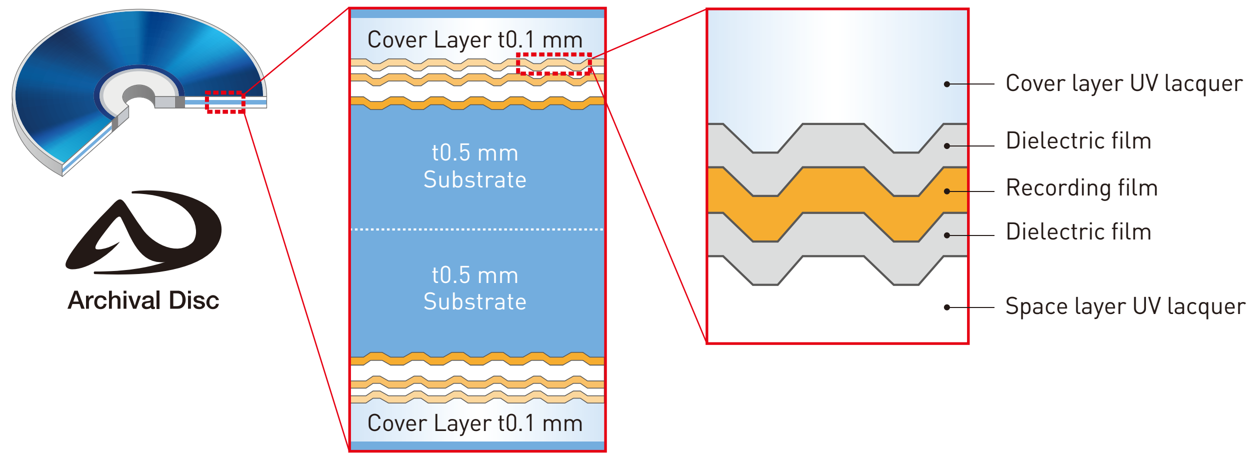


Source: Fujiwara-Rothchild, Ltd.

Mass Production of High-Density Optical Discs

To supply a large volume of high-density optical discs requires nano-scale precision in manufacturing as well as superior manufacturing technology and quality control capabilities. As shown in Figure 15, an Archival Disc is structured to have recording film in three layers per side, with six layers on both sides, and nano-scale construction is necessary. Thus, slight fluctuations in the process could reduce the recording quality or characteristics for long-term storage. By advancing the manufacturing technology for optical discs over 30 years, Panasonic has established manufacturing technology for multi-layered discs that had been difficult for mass production. The company has been making further efforts to create a stable supply and produce optical discs in greater quantities.

Figure 15 Structure of Recording Layers of an Archival Disc



Archival Disks have three recording layers per side and are double-sided.
The recording film has a simple structure with oxidized recording material sandwiched by oxidized insulator, providing high stability.

Source: Sony Corporation and Panasonic Corporation "White Paper: Archival Disc Technology July 2015"

Growing Network of Solution Partners

Specification requirements for storage media varies depending on the needs of clients. So it's essential for the provider to be able to offer flexible solutions and options for system configuration. Panasonic has been working to respond to the demand from wide range of customers by forming appropriate partnerships with other organizations. Followings are some examples.

Example 1: China Hualu Group (China)

Panasonic has established a joint venture company with Hualu Group Co., Ltd., a Chinese state-owned enterprise that the Chinese government established to grow the country's audio-visual device industry.

Both companies have been working in cooperation for the development and manufacture of archive devices that are suited for the Chinese market. In January 2016, the companies announced that they are building a large-scale data center in the city of Tianjin, China. The data center will have an area of 20,000 square meters in China Hualu Group's science and technology park, which has a total area of about 160,000 square meters. Optical disc storage with a total capacity of 1,000 PB will be installed in the center.

Example 2: Fujitsu (Japan)

Fujitsu Limited, a major system integrator in Japan, launched a low cost but highly reliable optical disc library, "FUJITSU Storage ETERNUS DA700," for the domestic Japanese market in May 2016. This system is a solution that combines the Data Archiver that Panasonic supplied as OEM with "Smart Contents Manager" software that Fujitsu developed. As it has capabilities for automatic extraction/addition and search of metadata, users can migrate data from primary storage to ETERNUS DA700 for archiving, based on the metadata of the content. Fujistu is also promoting the idea to use optical discs for the storage of big data.

Example 3: Raidix (Russia)

Panasonic Russia was at the forefront of Japanese companies to establish an R&D center and develop new projects at the Skolkovo Innovation Center in the suburbs of Moscow in Russia. In June 2016, the company signed a cooperation agreement with Raidix, LLC., a Russian software developer and Skolkovo startup.

Raidix is included in the register of the Ministry of Telecom and Mass Communications of the Russian Federation as recommended software for Russian companies and government agencies. Under the agreement with Panasonic Russia and Panasonic Corporation, Raidix will develop special software for Optical Disc Data Archiver and will market the software as a product "Made in Russia" on both the domestic and global market.

5 Expansion of the Market for Optical Discs

Factors Accelerating the Utilization of Optical Discs

There are two topics that are important to mention as we consider the growth factors for the utilization of optical discs. One is the handling of "non-structural data," which is the majority of cold data. Another is the trend of cold archives in data centers that store huge volumes of data. We will discuss these in detail here.

● Cold Archives for Non-Structural Data

"Non-structural data" is the term that describes unformatted data outside databases, such as e-mails, text documents, photographs, video clips, and other files. Data Archiver by Panasonic is compatible with erasure coding or object storage, which is optimal for storage of non-structural data requiring huge amounts of memory. Huge volumes of non-structural data are utilized in many industries, such as video content for movies/television production and post-production industries, still images and video content in medical and surveillance industries, image data for quality assurance in manufacturing, digitized data from paper documents, data from experiments in science, technology, and research organizations, etc. Considering this, the number of fields and the need for cold archives utilizing optical discs are expected to keep expanding.

● Cold Archives in Data Centers

Jay Parikh, Vice President of Facebook, unveiled a prototype for an archive system using 100 GB Blue-ray discs in January 2014 at the OCP U.S. Summit 2015 in San Jose, California in the U.S. This system was designed and tested as an option to archive the enormous volume of photographs and video clips that users upload to the data centers of Facebook. This system is expected to contribute to an 80 % reduction in energy consumption and a 50 % reduction in operating costs, compared to the existing storage system. This initiative by Facebook, a large-scale storage user, is significantly helping to grow interest in optical disc data archiving in the data center industry.

Examples of Applications Utilizing the Advantages of Optical Discs

So far, we have reviewed the strength of optical disc storage media for cold archives and discussed the potential for its market growth. Finally, we will focus on the following three points as applications to maximize the benefits of optical discs.

1. For Long-Term Archives

For storing data that needs to be preserved for a long time to comply with regulations or corporate policy.

2. For Backup

To be part of multiple duplication of active archives, optical discs can serve a role for backup. Utilization efficiency and reliability can be greatly improved by using optical discs in conjunction with other media such as HDDs, especially in cases where erasure-coding* is utilized.

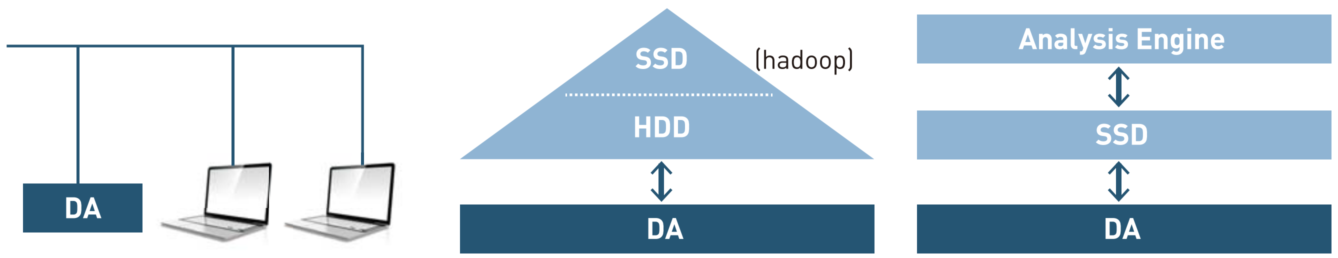
*Erasure coding: This enables the restoration of original content even when some of the divided data has been lost by storing divided content in physically separate nodes and adding erasure codes such as Reed-Solomon coding symbol. The length of the symbol can be around 20 % to 40 % of the size of the object. Thus, the utilization efficiency is higher than making two or three copies.

3. For Storing Big Data

Optical discs can be used to store content to be utilized as big data to create new corporate value. Such big data includes data from experiments in research organizations, inspection data in the manufacturing industry, IoT related data that has been collected from various sensors, etc. It is possible to utilize systems where data is stored in optical discs but then uses SSDs to transfer data at ultra-high speeds when the data is sent or being analyzed.

Figure 16 Examples of Applications Utilizing the Advantages of Optical Discs

For Long-Term Archives	For Backup	For Big Data or IoT
•Application Storing important data for long periods of time at low cost **•Requirements** Low cost per bit, long-term storage, authenticity, low power consumption **•Customers** Public sector, financial, broadcasting, manufacturing, etc.	**•Application** Configuring high response storage using SDDs/HDDs and Data Archiver to store its backup at a low cost **•Requirements** Low cost per bit, long-term storage, low power consumption **•Customers** SNSs (photographs, videos), Cloud storage services	**•Application** Storing large volume of data using Data Archiver and executes analysis using ultra-high-speed SDDs **•Requirements** Low cost per bit, long-term storage and authenticity, low power consumption **•Customers** Public sector, financial, broadcasting, manufacturing, etc.



*DA in the figure is the abbreviation for Data Archiver.

Transforming the Cold Archive Market

New generation optical disc storage systems with large capacity and high transfer rates are becoming a strong force to promote the implementation and utilization of cold archives. Expectations are high for the evolution of optical discs that will further accelerate the hot market for cold archives.

Figure 17 Expanding Applications of Optical Discs